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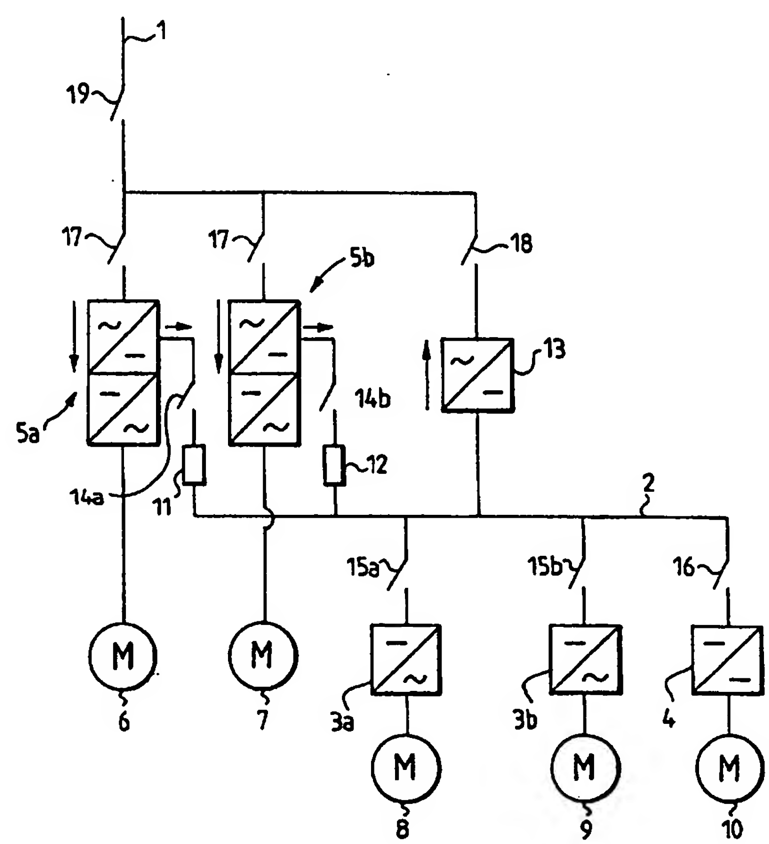
(54) Title: POWER SUPPLY ARRANGEMENT FOR A MULTIPLE ELECTRIC MOTOR LINE DRIVE

(57) Abstract

The invention relates to a power supply arrangement for a multiple electric motor line drive, the arrangement comprising means connected to an AC supply (1) for supplying a DC voltage to a DC intermediate circuit (2) to which electric motors (8, 9, 10) are connected via their respective frequency converters (3a, 3b)/choppers (4). In accordance with the invention, the arrangement comprises at least one rectifier frequency converter/chopper unit (5a, 5b) supplying its own motor (6, 7), and the means for supplying a DC voltage to the DC intermediate circuit comprise the rectifier section of the said at least one rectifier frequency converter/chopper unit (5a, 5b).



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Power supply arrangement for a multiple electric motor line drive

The present invention relates to a power supply arrangement for a multiple electric motor line drive. The arrangement comprises means connected to an AC supply for supplying a DC voltage to a DC intermediate circuit to which electric motors are connected via their respective frequency converters/choppers.

A DC intermediate circuit is a common characteristic of voltage-controlled motor supply units based on pulse width modulation. The most important connection benefit offered by such a DC intermediate circuit is a good cosfi when the DC voltage is maintained in the vicinity of the maximum value obtained from the mains. Another advantage is the internal power equalization of the DC system, since in a mains connection only active net power is transmitted, which again reduces losses in transformers and other supply units on the AC side. A third advantage is the relative simplicity of the convertors that supply the motors. In four-quadrant operation, only six controlled branches (AC) or four controlled branches (DC) are needed, whilst a four-quadrant DC drive directly connected to the line has twelve controlled branches. There also exists a two-branch twin quadrant version and one-branch single quadrant version of a DC chopper which is employed to supply DC motors. The advantage of simplicity is emphasized when several drives are connected in the same intermediate circuit. The DC intermediate circuit is, however, attended by the drawback of double energy conversion, which is complicated and gives rise to additional losses particularly in drives that are constantly under high load. Nevertheless, the losses are small compared with additional losses produced in

a conventional phase angle-controlled drive below the rated speed on the AC side. In such circumstances, the difference between the losses is very clear.

The conventional line drives of the kind described above implement the single drive concept. A diode bridge feeds an intermediate circuit wherefrom the motor supply unit, either a frequency converter for AC motors or a chopper for DC motors, derives its energy. Braking energy is supplied from the intermediate circuit via a chopper to a resistance braking unit or fed via an inverter back to the mains. The DC intermediate circuit makes it possible to decelerate the drive by utilizing the motor and supply unit losses, even though no actual braking unit were provided.

Figure 1 in the accompanying drawing shows an example of the construction of a conventional line drive of the kind described above. In the line drive of Figure 1, having several consumption points of very different sizes, a DC intermediate circuit 21 is fed by way of a common high-capacity line supply unit (rectifier) 20. As the power increases, the line supply unit must also be sectionally divided, the module size being dependent on the supply transformers that have maximum outputs of 1.6 to 4 MVA in the low-voltage range, depending on the secondary voltage. The actual restricting factor is the duration of the short-circuit current on the low-voltage side of the equipment. The line supply unit 20 in the embodiment of Figure 1 is a rectifier bridge supplying a low-inductance DC bus 21. AC motors 22 and 23 are supplied from this DC bus through frequency converters 24 and 25 and DC motor 26 through a chopper 27. The connection further comprises a filter capacitor 28 linking the DC bus to earthing isolation.

In equipment involving high moments of inertia or large masses to be transported, suitable dimensioning of the drive is a significant technical and economic factor. In papermaking machines, acceleration and deceleration times of about five minutes have been adopted. This makes the dimensioning of transmission means and motors less critical.

Applications involving particularly high moments of inertia include drying cylinder blocks, leading rollers, and winder. Leading roller motors have power ranges of 5-30 kW and drying cylinder block and winder motors 100-250 kW. The average load in continuous drive is normally 20-30% of the design value. Stopping of such drives requires dynamic braking, i.e. power control from the DC intermediate circuit to a braking resistor unit or, to avoid losses, preferably feedback to the mains.

Applications involving predominantly friction-type loads include the wire and press section of a papermaking machine. The wire section may include drive points of very heavy duty, 500-1000 kW. The efficiency of a continuous drive is about 60-80% of the design value. These drives have traditionally been stopped using the friction of the equipment, the method thus being simply to switch off the power supply from the electric drive, with no feed to the mains or resistance braking. The term used for this method is coasting.

In a line drive for a papermaking machine in particular, several (4-5) large drives having an average size of e.g. 300 kVA and a plurality (10-20) of smaller drives having an average size of 20 kVA are connected to the same transformer having an output of 2500 kVA, for instance. Such a system has conventionally the following configuration: the supply block comprises 4-6 fields having a combined length of 3.2 m and

comprising a switch, a semiconductor unit (e.g. a two-way thyristor bridge), an LC filter, interface units for the AC and DC sides and control relays. There are five larger drive groups, having a combined length of 3 m. These comprise as main parts a fuse isolator and a frequency converter. Fifteen smaller drive groups are provided, having a combined length of 6 m and similar main parts as the larger drive groups.

The proportion of the supply in the total length of the equipment is 26%. If there are fewer drive groups, the proportion of the supply in the total length of the equipment increases. The cost effect of the supply group tends to be even higher than its proportion in the length of the equipment. Factors affecting this include the high cost of filtering capacitors, the number of supply groups in comparison with the number of drive groups, the fact that the production numbers of the actual single drives are hundredfold as compared with the supply groups, and the fact that the supply groups comprise a wide variety of application-specific detail solutions. On account of the above factors, the benefits of serial production can be taken advantage of in the manufacture of supply groups only to a limited degree.

It is an object of the present invention to provide a novel power supply arrangement wherewith the proportion of the supply group in the total length of the equipment can be diminished and substantial savings in costs achieved, particularly if units produced in large series are employed.

In the arrangement of the present invention, the proportion of the supply group can be diminished by means of the construction according to the invention, which is characterized in that the arrangement comprises at least one rectifier frequency converter/

chopper unit supplying its own motor, and that the means for supplying a DC voltage to the DC intermediate circuit comprise the rectifier section of the said at least one rectifier frequency converter/chopper unit.

The basis for the arrangement of the invention is the idea that the advantages of a DC intermediate circuit specifically relate to the rectifying action and not as much to high powers to be transmitted. The rectifying applies both to the voltage, which must be close to the maximum voltage obtained from the line (which is achieved by way of diode supply), and to the motor power, more specifically its flow direction. The fact that the filters of prior power supply arrangements employ costly, large capacitor bank units has bearing on centralized power supply in particular. In the power supply arrangement of the invention, the AC power is supplied to large drive groups having a diode bridge and a frequency converter manufactured in large series. On the AC side, the common protective device is normally a switch. The filter capacitors are re-divided into drive groups, and thus there is no need to transport the harmonics produced by the chopping action for long distances in the DC circuit, thus making the low-inductance requirements on the circuit less severe.

When there are at least two integrated rectifier frequency converter/chopper units in the power supply arrangement of the invention, their rectifier sections are connected in parallel to the DC intermediate circuit by way of inductances. Thus the rectifier sections of large frequency converters are connected in parallel to supply the DC intermediate circuit by way of small inductances. Typically this supply can be provided for through the connections of the braking chopper of the frequency converters. The purpose of the inductances included in the connection

is to produce a static state in the parallel connection, which means a certain amount of resistivity. The inductance also limits the speed of current rise in a short-circuit situation, in which case the protective fuses are selective.

In the power supply arrangement of the invention, the DC intermediate circuit is preferably connected via an inverter to an AC supply for braking the motors connected to the DC intermediate circuit. This inverter connected to the DC intermediate circuit thus brakes into the mains. The inverter is based on prior art line commutation or forced commutation technology. Compared with an antiparallel-connected thyristor bridge, this braking mode affords better short-term loadability on the braking side in the supply, since the motor side does not generate any basic thermal load, which is common in the present-day bridge constructions. If dynamic braking is not needed, the inverter may be omitted. Also in that case, the motor and supply unit losses can be utilized to enhance the braking by coasting.

In the power supply arrangement according to the invention, the sectional division of the power supply in the above manner is based on the above-stated dimensioning/design principle according to which the thermal load on massive drive groups varies over the range 20-80%, and thus the remaining rectifying capacity can be utilized in the smaller groups. The power ratios are approximately 1:10 in typical applications.

The power supply arrangement of the invention will now be described in greater detail with reference to the accompanying drawing, in which

Figure 1 shows a power supply arrangement according to the prior art, and

Figure 2 is a schematic view of a power supply arrangement according to the present invention.

The power supply arrangement according to the invention as described in Figure 2 for a multiple electric motor line drive comprises two integrated rectifier frequency converter units 5a and 5b arranged to supply AC motors 6 and 7. The rectifier sections of these rectifier frequency converter units 5a and 5b are connected via fuse isolators 14a and 14b and small inductances 11 and 12 in parallel to the DC intermediate circuit 2. AC motors 8 and 9 of substantially lower power ratings than motors 6 and 7 are connected to the DC intermediate circuit 2 via fuse isolators 15a and 15b and frequency converters 3a and 3b. The motors 6 and 7 in practice have a power rating at least twice the power rating of the motors 8 and 9. The DC intermediate circuit further has connected to it a DC motor 10 supplied from the DC intermediate circuit 2 via a fuse isolator 16 and chopper 4. For braking of motors 8, 9 and 10, the connection further includes a frequency converter 13, by way of which electric power can be supplied from the DC intermediate circuit 2 to an AC supply 1. Both the rectifier frequency converter units 5a, 5b and the inverter 13 are connected to the AC supply via fuse isolators 17a, 17b and 18. The entire line drive can be isolated from the AC supply by way of a switch 19.

In the above, the power supply arrangement of the invention has been illustrated by means of one exemplary embodiment only, and it is to be understood that a variety of modifications may be made therein without departing from the scope defined by the appended claims. Thus there may be a greater number than described of large rectifier frequency converter/ chopper units the rectifier section of which supplies

the DC intermediate circuit. Typically also the number of smaller drives provided in connection with the DC intermediate circuit is distinctly greater than in the embodiment shown in Figure 2.

Claims:

1. A power supply arrangement for a multiple electric motor line drive, the arrangement comprising means connected to an AC supply (1) for supplying a DC voltage to a DC intermediate circuit (2) to which electric motors (8, 9, 10) are connected via their respective frequency converters (3a, 3b)/choppers (4), characterized in that the arrangement comprises at least one rectifier frequency converter/chopper unit (5a, 5b) supplying its own motor (6, 7), and that the means for supplying a DC voltage to the DC intermediate circuit comprise the rectifier section of the said at least one rectifier frequency converter/chopper unit (5a, 5b).

2. A power supply arrangement as claimed in claim 1, characterized in that there are at least two rectifier frequency converter/chopper units (5a, 5b) and that their rectifier sections are connected in parallel to the DC intermediate circuit (2) via inductances (11, 12).

3. A power supply arrangement as claimed in claim 1 or claim 2, characterized in that for braking of the motors (8, 9, 10) connected to the DC intermediate circuit (2), the DC intermediate circuit is connected to the AC supply (1) via an inverter (13).

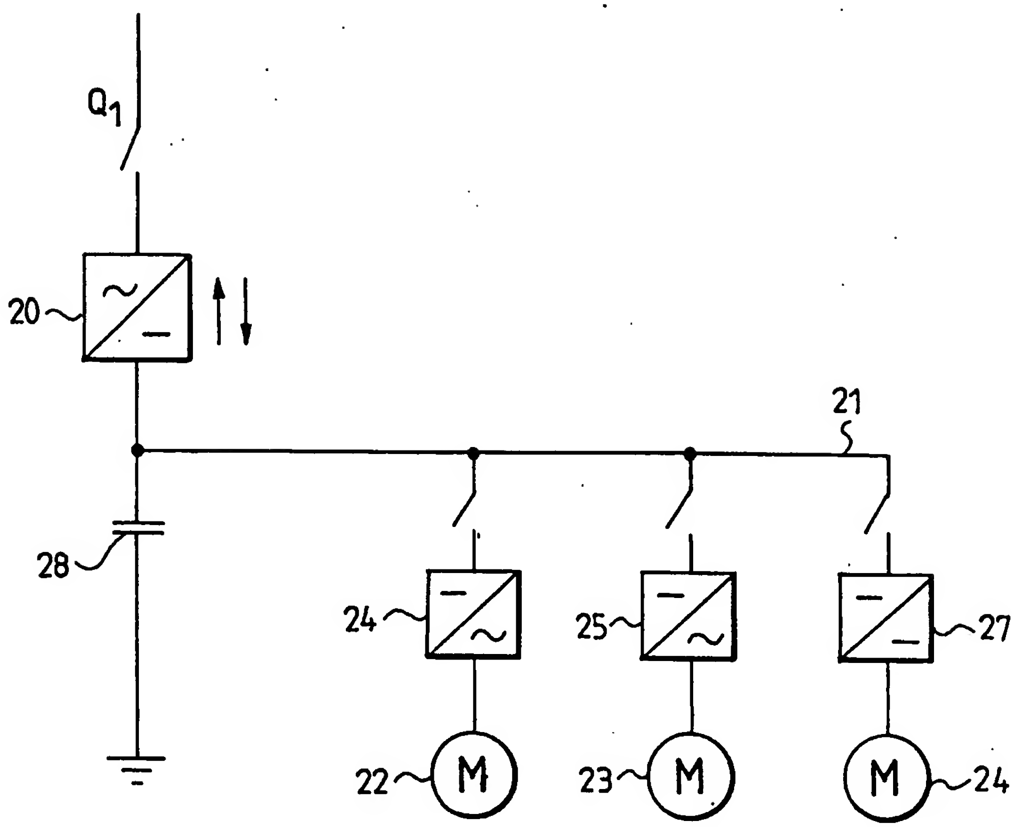

FIG. 1

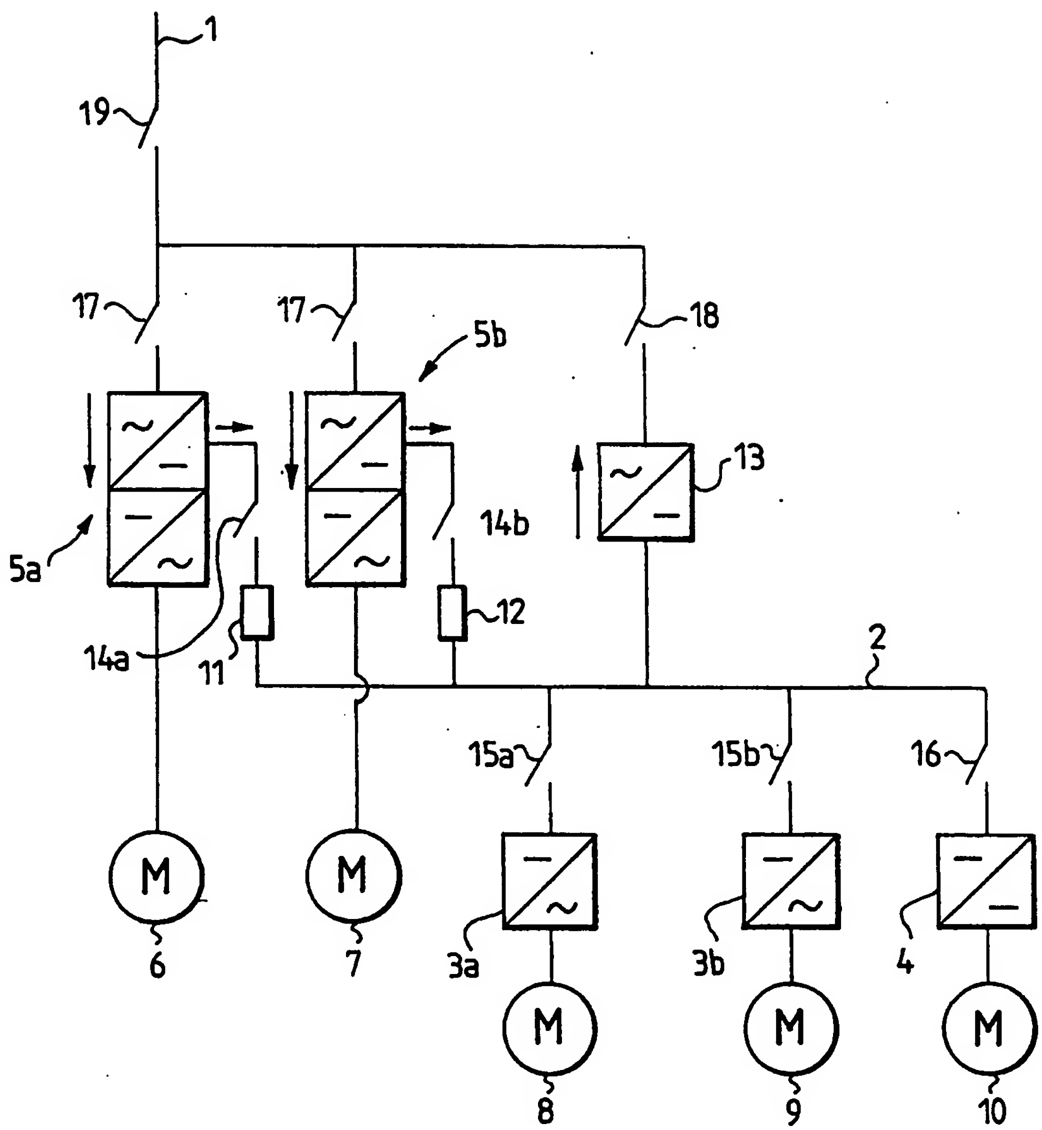
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FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 94/00382

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02M 5/40 // H 02 P 7/74, H 02 P 5/46
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02P, H02M, H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DIALOG - WPI, CLAIMS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 5237494 (UWE BAADER ET AL.), 17 August 1993 (17.08.93), column 2, line 28 - column 3, line 39 --	1-3
A	DE, C1, 3641569 (SKF TEXTILMASCHINEN-KOMPONENTEN GMBH), 24 March 1988 (24.03.88), abstract --	1-2
A	Patent Abstract of Japan, abstract of JP 2-266892 (A), 31 October 1990, (YASKAWA ELECTRIC MFG CO LTD) --	3

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4263535 (BYRON M. JONES), 21 April 1981 (21.04.81), abstract -- --------	1-3

INTERNATIONAL SEARCH REPORT
Information on patent family members

29/10/94

International application No.
PCT/FI 94/00382

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